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On the Antiquity of Trisomy 21: Moving Towards a Quantitative Diagnosis of Down Syndrome in Historic Material Culture

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ABSTRACT

Down syndrome was first medically described as a separate condition from other forms of cognitive impairment in 1866. Because it took so long for Down syndrome to be recognized as a clinical entity deserving its own status, several investigators have questioned whether or not Down syndrome was ever recognized before 1866. Few cases of ancient skeletal remains have been documented to have Down syndrome-like characteristics. However, several forms of material culture may depict this condition. Within this paper the history of our understanding of Down syndrome is discussed. Both skeletal remains and different forms of material culture that may depict Down syndrome are described, and where relevant, debates within the literature about how likely such qualitative diagnoses are to be correct are also discussed. Suggestions are then made for ways in which a quantitative diagnosis can be made to either strengthen or weaken qualitative arguments for or against the diagnosis of Down syndrome in different forms of historic material culture.

INTRODUCTION

Down syndrome was first described in the medical literature by John Langdon Down in 1866. During this era individuals with cognitive impairment (i.e. mental retardation) were often referred to as “idiots” and “imbeciles” and rarely differentiated into subcategories based upon differential diagnoses. Using a hierarchical racial classification system that was popular during his age, John Langdon Down noted the resemblance of facial features among individuals with Down syndrome and individuals of Mongolian descent (Down 1866; Volpe 1986). Down also noted the characteristic facial appearance and shared phenotypic features of unrelated individuals with Down syndrome in the following: “[...] when placed side by side, it is difficult to believe that the specimens compared are not children of the same parents” (Down 1866: 260). Based upon these observations Down determined that individuals with Down syndrome differed from other types of individuals with cognitive impairment and labeled these individuals as “Mongolian idiots” or “mongoloids” (Down 1866:260-261). Although other authors (e.g. Esquirol and Seguin as cited in Stratford 1996: 3-4) may have described individuals with Down syndrome before Down’s publication in 1866, Down is credited with being the first person to group together individuals with Down syndrome based upon their phenotypic similarities to define a subcategory of individuals with cognitive impairment (Megarbane et al. 2009; Stratford 1996; Pueschel 2000).

The hierarchical racial ladder of Down’s era viewed the races of mankind as being fixed and definite, with Caucasians being superior to all other races and Mongolians being at the bottom of the ladder (Volpe 1986). Although Down’s “Mongolian idiot” and “mongoloid” labels would be viewed as racist today, the use of these terms was a consequence of the prevailing ideas of racial hierarchies from his era (Volpe 1986). By combining this interpretative framework with his phenotypic observations of individuals with Down syndrome, Down made an argument for the “unity of the human species” (Down 1866). Down reasoned that if a disease can break down supposedly “fixed” racial barriers by producing a Mongolian-like child from non-Mongolian parents, then the racial categories of mankind are likely not fixed at all and quite variable (Down, 1866:262). This was an unpopular opinion at the time of Down’s publication. Interestingly, if Down had not favored this hierarchical racial classification system for understanding differences between individuals with cognitive impairment, it is likely that it would have taken much longer for medical scientists to classify Down syndrome as different from other forms of cognitive impairment.

After Down’s classification of Down syndrome many investigators attempted to document exactly how individuals with this condition differ. Several studies have determined that individuals with Down syndrome differ phenotypically from individuals who do not have Down syndrome in many ways. General differences include the following: almond-shaped eyes (Shuttleworth 1886; Oliver 1891), oblique palpebral fissures (Muir 1903), an open-mouthed facial posture that may include a protruding tongue, broad and stocky necks, obesity (Pueschel 2000), short, broad, and small hands and feet (Fraser and Mitchell 1876-7; Chumlea et al. 1979), hands may have a simian palmar crease (Hall 1966), inward curving little fingers (Smith 1896; Muir 1903), a wide space between first and second toes (Pueschel 2000:55), and a high frequency congenital heart defects (Garrod 1898). Before karyotyping was possible, individuals with Down syndrome were usually diagnosed based upon differences in craniofacial characteristics. Osseous craniofacial differences include the following: brachycephalic-shaped heads (Fraser and Mitchell 1876-7) small or absent nasal bones (Jones 1890; Greig 1927a), an underdeveloped mandible and maxilla (Benda 1941), flat or concave midfaces (Greig 1927b),

poor or absent sinus development (Spitzer and Robinson 1955; Roche et al. 1961), smaller palates (Redman et al. 1966), poor or absent tooth morphogenesis and highly variable tooth eruption sequences (Jones 1890; Greig 1927b; Townsend 1987), and reduced rates of craniofacial growth overall (O’Riordan and Walker 1978; von Hofe 1922). Soft-tissue craniofacial differences include the following: prominent forehead (Volpe 1986), epicanthic folds (Shuttleworth 1886; Oliver 1891), a flat or depressed nasal bridge, upturned nose (Jones 1890; Greig 1927a), midfacial hypoplasia (Kisling 1966; Frostad et al. 1971), small mouth (Pueschel 2000), folded over upper helix of ear (Hall 1966), poor craniofacial musculature differentiation (Bersu 1980), reduced overall facial size (Benda 1941), and a relatively short face (Gollesz 1961) that can be square-like when viewed anteriorly (Fraser and Mitchell 1876-7). These lists are by no means exhaustive. The facial phenotype exhibited depends on genetic background, type of chromosomal abnormality causing Down syndrome (e.g. non-disjunction, translocation, or mosaicism), age, and sex (Pueschel 2000). The overwhelming consensus is that the craniofacial phenotype of Down syndrome always shows some degree of facial dysmorphology; however, no single phenotypic difference is always present (Pueschel 2000).

In 1959 LeJeune discovered that an extra copy of human chromosome 21 (i.e. trisomy 21) causes Down syndrome (LeJeune et al. 1959); however, Waardenburg inferred this in 1932 (Allen 1974). Chromosome 21 contains about 1.5% of the human genome and has an estimated 300-400 protein coding genes (Gardiner et al. 2003; Hattori et al. 2000; Megarbane et al. 2009). Specifically, the Down syndrome genotype can occur from nondisjunction, translocation, and mosaicism; however, nondisjunction is by far the most frequent cause of Down syndrome (~95%) (Fisher 1983; Hassold et al. 1993). Trisomy 21 is responsible for causing the abovementioned phenotypic differences by causing a gene-dosage imbalance that disrupts development.

Genetic lines of evidence indicate that the ancestral human chromosome 21 arose 30-50 mya (Richard and Dutrillaux 1998). Interestingly, the condition of trisomy 21 is not limited to humans. In non-human apes chromosome 22 is analogous to human chromosome 21. Humans have two less chromosomes than our ape cousins because of a chromosomal fusion that occurred several million years ago to produce human chromosome 2 (Kasai et al. 2000; Wienberg et al. 1994; Yunis and Prakash 1982). Trisomy 22 is the genetic equivalent of Down syndrome in apes and has been reported in both a chimpanzee (McClure et al. 1969) and orangutan (Andrle, 1979). Taken together, these lines of evidence indicate that trisomy 21 has an incredibly long history in the primate lineage.

Today we know that Down syndrome is found in all ethnic backgrounds and socioeconomic statuses at a frequency of about 1:700 (Kuppermann et al. 2006; CDCP 2006). A marked maternal age effect has also been noted (von Hofe 1922; Penrose 1951; Hook 1989). On average more than 700 Down syndrome children are born each day worldwide and more than 255,000 individuals with Down syndrome are born each year. Due to improved healthcare, the life expectancy for individuals with Down syndrome has consistently risen from 9 years in 1900, to 30 years in the 1960’s, and to more than 50 years today (Collman and Stoller 1962; Megarbane et al. 2009), which has resulted in an increase in prevalence (Einfeld and Brown 2010). However, the average lifespan of 9 years in 1900 may have been skewed due to a cultural tendency to institutionalize cognitively impaired individuals during this time period combined with the poor living conditions and developmental outcomes associated with many of these institutions (Stimson et al. 1968; Kugel 1961). It is possible that in some cultures individuals

with Down syndrome who did not have severe health problems may have enjoyed a higher average lifespan (Stratford 1982:250-254).

There is debate within the literature about the age of Down syndrome as a condition affecting mankind. Down syndrome is the most common live-born aneuploid condition in humans; however, this condition was not described medically until 1866 (Down 1866). The high prevalence of Down syndrome relative to other genetic anomalies and the length of time it took for this condition to be described medically has caused some authors to question whether or not Down syndrome is a relatively old or new condition in humans (Mirkinson 1968; Volpe 1986). However, Pueschel (2000:11) provides three reasons for why Down syndrome was not recognized as a clinical entity before 1866: 1) prior to the 19th century few physicians were interested in children with developmental disabilities, 2) many diseases and disorders were more prevalent then, which would have overshadowed the occurrence of Down syndrome, and 3) at this time period only half of the female population survived past the age of 35, which would reduce the number of late aged pregnancies that are more likely to produce a child with Down syndrome. Furthermore, Richards (1968: 353-354) pointed out that population size, population age-structure, and infant mortality probably heavily influenced the prevalence (i.e. number of babies surviving) of Down syndrome and precluded medical science from recognizing this condition earlier. However, medical conditions have frequently been identified in historical material culture (Salter 2008). Phenotypically- and historically-speaking the condition of Down syndrome may be represented in skeletal material and several forms of material culture from various populations that are both spatially and temporally discrete. Within this paper I provide an extensive list and description of skeletal remains and material culture that may depict Down syndrome (Appendix A) and, where relevant, I discuss debates within the literature about how likely such qualitative diagnoses are to be correct. I then make suggestions for ways in which a quantitative diagnosis can be made to either strengthen or weaken the qualitative arguments for or against the diagnosis of Down syndrome in historic material culture.

SKELETAL MATERIAL

SRI-3 skeletal remains (circa 5200 B.C.)

Walker and colleagues (1991) published an abstract on 7200 year old skeletal remains (SRI-3) from Santa Rosa Island, CA, which were found in a Native American cemetery. This individual's sex was estimated to be female. Cranial characteristics included the following: metopism, very wide interorbital distances, a low and wide nasal aperture, reduced auricular height, a flat cranial base, small teeth, and a dysmorphic peg-shaped third molar. Overall, the dimensions of the mandible, palate, and cranial vault were similar to those of other SRI-3 females. Walker and researchers also recovered a femur, a fragmentary os coxa, and three cervical vertebrae (C1-C3), many of which were also unusually small. Walker and colleagues noted that several of these skeletal characteristics are consistent with those found in Down syndrome; however, given the lack of a representative skeletal collection of individuals with Down syndrome, this diagnosis was not conclusive. Unfortunately, Dr. Walker's untimely passing has prevented more detailed publications about this individual, but Dr. Della C. Cook from Indiana University intends to publish further on these skeletal remains (personal communication). If this individual had Down syndrome it would be the oldest recorded and most complete historical skeletal material with this condition to date.

Tauberbischofsheim skull (circa 550 B.C.)

Czarnetski and colleagues (2003) briefly describe 2550 year old craniofacial skeletal remains from a burial site at Tauberbischofsheim, Germany. This individual's sex was estimated to be female, and she was estimated to be 18-20 years of age at the time of death. Unfortunately a detailed description of the skull was not provided. Also, while the authors provided a picture of a Down syndrome skull, it is not clear whether or not the picture provided is of the skull in question (Czarnetski et al. 2003).

Breedon-on-the-Hill skull (circa 700-900 A.D.)

Brothwell (1960) published a detailed description of a skull from Leicestershire, England dated to 700-900 A.D, which is probably the most reliable diagnosis of Down syndrome in historical skeletal material due to the level of anatomical detail provided, photographic evidence provided (Figure 1), the caution used by the author during assessment, and the ability of the author to compare this individual to the population from which it is assumed to come from (Berkson 2004). This skull was excavated from the Breedon-on-the-hill burial site – a late Saxon burial ground that may have been associated with a monastery. As of Brothwell's 1960 publication date, approximately 200 individuals had been excavated from this site. This individual's age was tentatively estimated to be 9 years based on dental eruption and a patent basisphenoid synchondrosis; however Brothwell notes that if this individual had Down syndrome then the age estimate would be inaccurate because it is based upon growth and tooth eruption patterns of typical individuals whereas Down syndrome craniofacial ontogeny, tooth eruption sequence, and timing can significantly depart from what is normally expected. Brothwell noted that the skull in question exhibited the following characteristics: microcephaly, brachycephaly, a small calvarium, reduced skull length, thin cranial vault bones (similar to that found in 3 year olds), reduced upper facial height, a small maxilla and malar bones, a robust mandible, mandibular prognathism, and irregular tooth root development resulting in a 45° rotation of several of the canines and incisors, which were also small. The cranial capacity of this skull was estimated at 835 cubic centimeters (cc), whereas an age-matched sample of typical skulls ranged from 1130-1290 cc. Because a representative skeletal sample of individuals with Down syndrome does not exist, Brothwell compared the Breedon-on-the-hill skull with the three Down syndrome skulls described in detail and photographed by Greig (1927a; 1927b) and found enough similarities to make a convincing diagnosis of Down syndrome for this skull. It is also

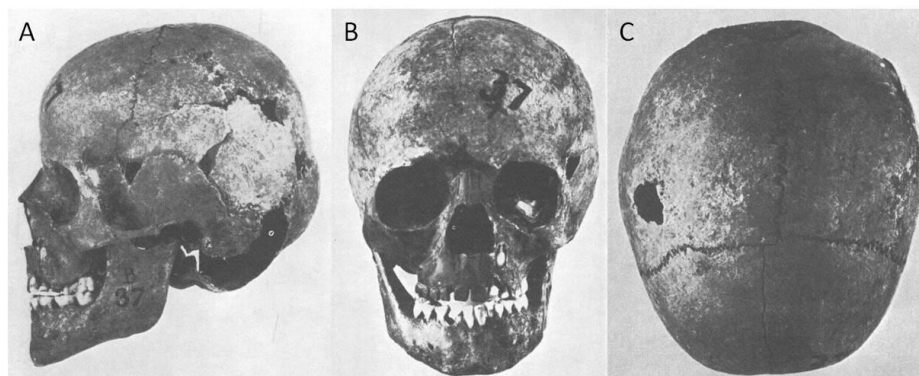


Figure 1: Images of the Breedon-on-the-Hill skull published by Brothwell (1960:143).

noted that the close proximity of a monastery may have increased this individual's likelihood of survival (Brothwell 1960; Stratford 1996:7).

Images A, B, and C show a lateral, anterior, and superior view of this skull. This skull is suspected to have belonged to an

individual with Down syndrome who was estimated to be around 9 years of age at the time of death. The evidence that led Brothwell to tentatively conclude that this individual had Down syndrome included the following list of characteristics present in this specimen, which are also frequently found in individuals with trisomy 21: reduced cranial capacity, microcephaly,

brachycephaly, small calvarium, reduced skull length, very thin cranial vault bones, reduced upper facial height, small maxilla and malar bones, a robust mandible, mandibular prognathism, and irregular tooth root development.



Figure 2: *Lady Cockburn and her children* painting by artist Joshua Reynolds (1723-1792) dated to around 1173 A.D.

PAINTINGS

Lady Cockburn and her Children: A cautionary tale

In order to discuss possible depictions of Down syndrome in historical paintings it is necessary to discuss a painting by Joshua Reynolds (1723-1792) called *Lady Cockburn and her Children* (Figure 2). This painting appeared to depict a child with Down syndrome, but the child in question

grew up to be Admiral George Cockburn of the British Fleet, who is famous for transporting Napoleon Bonaparte on his ship into exile on St. Helena. Thus, many investigators have argued that this child probably did not have Down syndrome (Zellweger 1968:458; Volpe 1986:427; Pueschel 2000:10-11; Ward 2004:220), and adult pictures of Admiral George Cockburn seem to prove these assertions true¹.



Figure 3: *The Adoration of the Shepherd* painting by Jacob Jordaens (1593-1678) dated to around 1618 A.D. Image A depicts a woman holding a child with suspected Down syndrome-like facial characteristics (Zellweger 1968). Image B is a close-up image of this child's facial features.

The Adoration of the Shepherd (circa 1618 A.D.)

In 1968 Mirkinson questioned whether or not Down syndrome is a modern disease. He noted a lack of material culture depicting this condition and suggested that Down syndrome may have been so uncommon before the 19th century that it had never been represented in material culture by

¹ Figure 2 was reproduced with permission © National Gallery Image Library. Reproduction of any kind is prohibited without express written permission in advance from The National Gallery Image Library.

artists (Ward, 2004). Mirkinson (1968) challenged readers of the *Lancet* to search for historical depictions of Down syndrome in pre-modern material culture. Zellweger (1968) responded to Mirkinson's challenge by pointing out a Jacob Jordaen (1593-1678) painting titled *The Adoration of the Shepherd* (Figure 3) that is dated to 1618 A.D. In this painting a woman is holding a child who may have Down syndrome. However, while upslanted palpebral fissures are readily apparent, other Down syndrome-like characteristics are lacking. Interestingly, Stratford (1996:9) claims that Jordaen and his wife Catherine van Noort had a daughter named Elizabeth who had Down syndrome; however, evidence to validate this assertion is lacking².

Satyr with Peasants (circa 1635-1640 A.D.)

Zellweger (1968) also argues that Down syndrome may be depicted in another Jacob Jordaen painting titled *Satyr with Peasants* (listed as *The Peasant and the Satyr* by Zellweger). This painting (Figure 4) reportedly shows the same woman from *The Adoration of the Shepherd* about 20 years older holding another child who may have had Down syndrome (Zellweger,



Figure 4: *Satyr with Peasants* painting by Jacob Jordaens (1593-1678) dated to between 1635-1640 A.D. Image A depicts a woman holding a child with suspected Down syndrome-like facial characteristics (Zellweger 1968). Image B is a close-up image of this child's facial features.

1968). The child in this painting exhibits upslanted palpebral fissures and what may be a protruding tongue. Interestingly this painting is dated to about 20 years after the original painting, leading Zellweger (1968) to conjecture that these two paintings may depict the first recorded instance of multiple cases of Down syndrome in a family, which rarely occurs even

today. However, it is not entirely clear that the woman in each picture is the same women, and the child in both *The Adoration of the Shepherd* and *Satyr and Peasants* is not portrayed with many Down syndrome-like features. Overall, the qualitative evidence that Down syndrome may be depicted in *The Adoration of the Shepherd* and *Satyr with Peasants* paintings is very weak³.

² This image was published by Zellweger (1968:458) and is available at the following website: <http://www.jacobjordaens.org/Adoration-of-the-Shepherds.html>.

³ Zellweger (1968) argues that the woman holding the child in this painting is an older version of the woman in the painting from figure 3. This led Zellweger to conjecture that these two Jacob Jordaens paintings may represent the first recorded instance of multiple cases of Down syndrome in a single family. This image is available at the following website: <http://www.jacobjordaens.org/Satyr-with-Peasants.html>.

Ecce-homo-scene (circa 1505 A.D.)

Kunze and Nippert (1986) published an image of an ecce-homo-scene painting believed to depict an individual with Down syndrome (Figure 5). This painting is dated to around 1505 A.D. and is attributed to the craftsman of the Aachen alter.



Figure 5: *Ecce-homo-scene* painting attributed to the craftsman of the Aachen alter dated to around 1505 A.D. Image A depicts a child with suspected Down syndrome-like facial characteristics being groomed by a monkey (Kunze and Nippert 1986). Image B is a close-up image of this child's facial features (Kunze and Nipert (1986:83).

The painting depicts a lateral view of a child's face with oblique palpebral fissures, a depressed nasal bridge, an open mouth posture, a clefted chin, and the child appears to have a short and broad neck. Interestingly, a monkey is depicted grooming the child's hair. Kunze and Nippert (1986) note that this child is portrayed with the characteristic facial dysmorphology associated with trisomy 21. Overall, the qualitative evidence that the child portrayed in this painting may have had Down syndrome is strong.

Madonna and Child (circa 1460 A.D.)

Cone (1968) also responded to Mirkinson's challenge and directed attention to a previous publication in which he argued that the child in Andrea Mantegna's (1431-1506)

painting titled *Madonna and Child*, which is thought to depict the baby Jesus, had Down syndrome (Cone 1964; Pueschel 2000). This painting shows a woman wearing a light-blue hooded robe and an orange tunic who is holding a child portrayed with Down syndrome-like facial features (Stratford 1996:8). Both the mother and child have a round shape around their heads. Cone noted (1964) that the child in this painting had suggestive features of Down syndrome including oblique eyes, possible epicanthic folds, a small nose, an open mouth, and an adenoidal expression⁴.

Virgin and Child (circa 1460 A.D.)

Interestingly, Ruhrah (1935) argued that a child in another of Mantegna's paintings titled *Virgin and Child* displays Down syndrome-like characteristics. This painting (figure 6) also portrays a woman holding a child with Down syndrome-like phenotypic features. The child in this painting exhibits oblique eyes, possible epicanthic folds, a small nose, an open mouth, an adenoidal expression, a prominent tongue, square hands, an incurving little finger, a wide

⁴ This image was published by Cone (1964:133) and can be found on the web by doing an image search for "Madonna and Child" and looking for the robed mother and child described above.

spacing between the first and second toes of the foot, and a short and broad neck (Ruhrah 1935; Stratford 1982). Ruhrah felt that this child exhibited features consistent with Down syndrome or cretinism (Cone 1964; Volpe 1996; Ward 2004)⁵.

Figure 6: *Virgin and Child* painting by Andrea Mantegna (1431-1506) dated to around 1460 A.D. Image A depicts a woman holding a child with suspected Down syndrome-like facial characteristics (Ruhrah 1935; Cone 1964; Ward 2004).



The curators at the Museum Fine Arts, Boston requested that the following statement be included in this paper after discussing the *Virgin and Child* piece:

The Museum of Fine Arts, Boston, where this painting has been part of the collection since 1938, does not believe that any resemblance in this painting to the physical characteristics associated with trisomy 21 was intentional. Rather, the painter of the Boston picture (who museum curators believe is not Mantegna himself) was of limited ability, and in trying to emulate Mantegna's style, he produced a picture that coincidentally has some physical characteristics of that chromosomal abnormality. Note that, in the art historical literature on the influential artist Mantegna, museum curators have found no mention of him depicting children with what might be seen as disabilities. The Museum, instead, believes that any perceived resemblance is due to the lack of skill on the painter's part and a matter of the state of preservation of the painting.

⁵ Figure 6 was reproduced with permission © Museum Fine Arts, Boston. Reproduction of any kind is prohibited without express written permission in advance from The Museum Fine Arts, Boston.

Virgin and Child with Saints Jerome and Louis of Toulouse (circa 1455 A.D.)

Another painting that may depict a child with Down syndrome is the *Virgin and Child with Saints Jerome and Louis of Toulouse* painting, also attributed to Mantegna. This painting depicts a woman holding a child upright with a male figure on either side of her. The child in this painting is portrayed with Down syndrome-like features including widely spaced eyes, upslanted palpebral fissures, an open mouth expression, square-shaped hands with an incurving little finger, and a prominent tongue. This child looks very similar to the child depicted in both the *Madonna and Child* and *Virgin and Child* paintings⁶.

All three of Mantegna's paintings, which may depict a child with Down syndrome, were painted around the same time. Each child exhibits several phenotypic features associated with Down syndrome. It is possible that the same model was used for each painting; however, Stratford (1996:8) speculates that Mantegna was painting his own child or a child of the rich and powerful Gonzaga family of Mantua, Italy (Stratford 1982). Stratford (1996:8) claims that one of Mantegna's 14 children had Down syndrome and that the Gonzaga family hired him because one of their children also had the same condition. If a child with Down syndrome was born to the Gonzaga family, it may have lived a better life because of the prestige and wealth of this family during this time period (Stratford 1982); however, Stratford (1996:8) notes that the Gonzaga child in question reportedly died at the age of 4. It is also possible that Mantegna's artistic style simply portrayed young children in this fashion. Overall, the qualitative evidence that Down

syndrome may be depicted in the *Madonna and Child*, *Virgin and Child*, and *Virgin and Child with Saints Jerome and Louis of Toulouse* paintings is strong.



The Adoration of the Christ Child (circa 1515 A.D.)

In 2003 Levitas and Reid argued that a Flemish nighttime nativity painting titled *The Adoration of the Christ Child* (artist unknown) appears to have two individuals with Down syndrome depicted (Figure 7 A-C). One individual is shown with angel wings and the other is depicted as an earthly admirer (Levitas and Reid, 2003). Both of these individuals share a similar and distinctive facial appearance compared to other individuals

⁶ This image can be found on the web by doing an image search for "Virgin and Child with Saints Jerome and Louis of Toulouse" and looking for a mother holding a standing child who is flanked on either side by a male.



Figure 7: Two versions of the *The Adoration of the Christ Child* painting dated to around 1515 A.D. are provided here. Image A depicts several individuals in a nighttime nativity scene. Images B and C are close-up images of an angelic child and a shepherd child that appear to Levitas and Reid to have Down syndrome-like facial characteristics (Levitas and Reid 2003; Dobson 2003). Image D shows a different version of this painting depicting a daytime nativity scene where the individuals from image A appear to have a less distinctive and more normal appearance. Images E and F are close up images of the individuals from Image D which corresponds to image B and C from the nighttime nativity scene.

portrayed in this painting. The angelic individual has a flattened midface, epicanthic folds, upslanted palpebral fissures, small and upturned nasal tip, downward curving mouth corners, and short fingers with a widely spaced and curving small finger (Levitas and Reid, 2003). The earthly admirer, who appears to be a shepherd, is portrayed with a similar facial composition; however, the upslanted palpebral fissures are slightly longer and this individual has widely spaced eyes, which Levitas and Reid (2003) suggest may be an artistic misinterpretation of a flattened nasal bridge. It is worth noting that this individual shows an incurving little finger; however, the hand is gloved and grasping a Shepherd's horn, so this could be a consequence of grip rather than an artistic attempt to depict an incurving little

finger. It is also interesting to note that some of the flying angelic figures in the upper margin of the painting may show Down syndrome-like characteristics; however, their facial expressions complicate such an assessment.

Interestingly, there are two versions of this particular painting: one with the two individuals described above in a nighttime nativity scene (Figure 7 A-C) and one in which these individuals are replaced with individuals who do not have distinctive facial appearances in a daytime nativity scene (Figure 7 D-F). Based upon their qualitative facial analysis, Levitas and Reid (2003) conclude that the angelic individual (Figure 7B) had Down syndrome and the admiring shepherd may have had Down syndrome (Figure 7C). Furthermore, Levitas and Reid note that 16th century paintings typically depict individuals with disabling conditions as symbols of comedy or evil. According to Levitas and Reid this benevolent depiction of an angelic individual with a disabling condition such as Down syndrome suggests one of the following: individuals with disabilities were portrayed for symbolic purposes, the artist had warm feelings towards the models who had disabilities, or the physical signs of Down syndrome were not recognized at the time of this painting as a predictor of disability (Levitas and Reid 2003;

Dobson 2003). Overall, the qualitative evidence that Down syndrome may be depicted in *The Adoration of the Christ Child* is strong⁷.

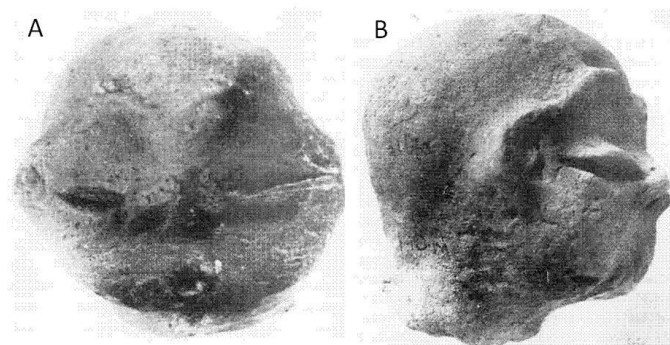


Figure 8: Neolithic Idol from West Thessaly, Greece dated to around 5000 B.C. Image A shows an anterior view and image B shows a lateral view of a 7000 year old idol suspected of having Down syndrome-like characteristics (Diamandopoulos et al. 1997). This image was originally published by Diamandopoulos and colleagues (1997:88).



Figure 9: Egyptian Figurine dated to around 100 A.D. that is suspected of having Down syndrome-like characteristics. Kunze and Nippert (1986:102) originally published this image and argue that this figurine has Down syndrome-like facial characteristics.

of a flattened nasal bridge, oblique palpebral fissures, small ears, a rounded face, and a small head. It is also noteworthy that this figurine exhibits an open mouth posture; however, the level

FIGURINES AND POTTERY

Neolithic Idol Figurine (circa 5000 B.C.)

Diamandopoulos and colleagues (1997) present a Neolithic period clay idol figurine (Figure 8) dated to about 5000 B.C. from West Thessaly, Greece, which, at 7000 years of age, may be the oldest representation of Down syndrome in material culture (Berkson 2004). The idol in question is portrayed with upslanted palpebral fissures and a sinking nasal base, possibly from midfacial hypoplasia (Diamandopoulos et al. 1997). Unfortunately the quality of the images in this publication makes it difficult to view the facial details of this idol. Personal communication with Diamandopoulos indicated that this artifact is currently housed at the Volos Archaeological Museum in Thessaly, Greece; however, repeated attempts to contact the museum for higher quality images have been unanswered. Overall, based upon the scant evidence of Down syndrome in this figurine and the general facial outline of the poor quality anterior and lateral published images, the qualitative evidence that Down syndrome may be depicted in this Neolithic idol is currently weak.

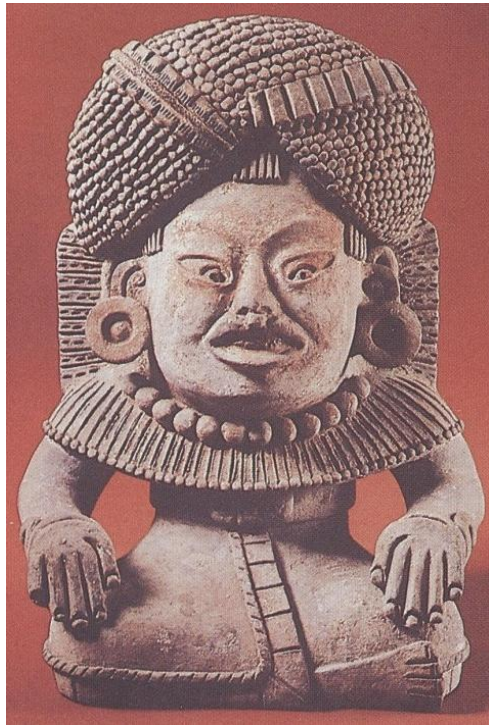
Egyptian Figurine (circa 100 A.D.)

Kunze and Nippert (1986) argue that an Egyptian figurine from around 100 A.D. depicts Down syndrome (Figure 9).

This diagnosis is based upon the presence

⁷ The images from Figure 7 were reproduced with permission under the Images for Academic Publishing (IAP) guidelines Image© Metropolitan Museum of Art. Reproduction of any kind is prohibited without express written permission in advance from The Metropolitan Museum of Art.

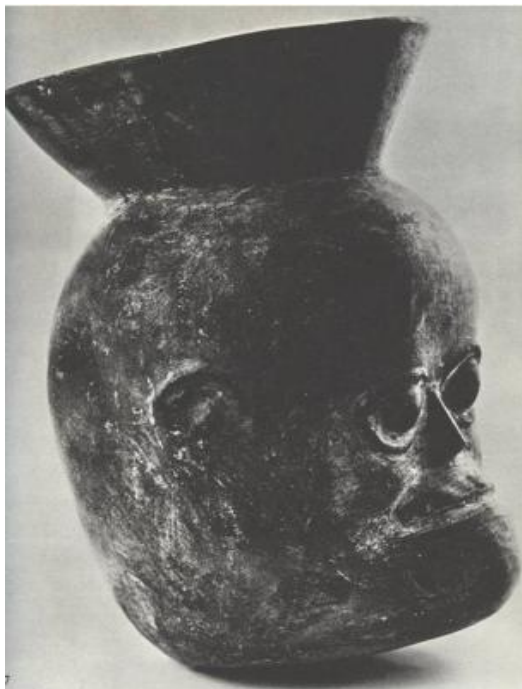
of anatomical detail for this figurine is poor. Overall, the qualitative evidence that Down syndrome may be depicted in this figurine is weak.



Goddess Figurine with Turban made of Pearls (400-800 A.D.)

Kunze and Nippert (1986) also argue that a figurine dated from 400-800 A.D. from the Monte Alban culture of Mexico depicts Down syndrome (Figure 10). This figurine portrays a goddess with a turban made of pearls. As evidence for this diagnosis, Kunze and Nippert note that this figurine has a rounded face and slanting palpebral fissures. It is also noteworthy that this statuette exhibits an open mouth posture; however, this figurine exhibits few qualitative characteristics associated with trisomy 21. Overall, the qualitative diagnosis that Down syndrome may be depicted in this figurine is weak.

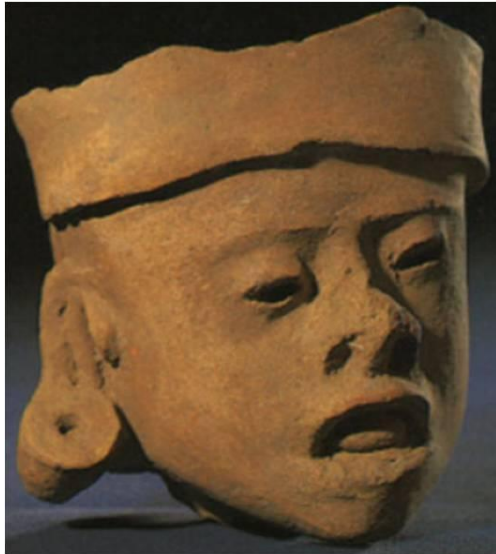
Figure 10: Goddess Figurine with Turban made of Pearls from the Monte Alban culture of Mexico (400-800 A.D.) that is suspected of having Down syndrome-like characteristics. Kunze and Nippert (1986:103) originally published this image and argue that this figurine has Down syndrome-like facial characteristics.



Pottery Vase (1200-1500 A.D.)

Ebbin and colleagues (1968) also responded to Mirkinson's challenge by directing attention to a book written by Calvin Wells. In this book Wells (1964) published an image of a pottery vase that may depict Down syndrome (Figure 11). This piece comes from Peru and is dated from 1200-1500 A.D. This vase depicts a human face with a bulbous forehead, large eyes, midfacial hypoplasia, and mandibular prognathism. The facial profile suggests a concave appearance. Part of the upper ear can be seen but it is unclear if it was unfinished by the artist or if the ear broke off from the piece. While the artistic detail of this pottery vase is crude, the facial profile and features are suggestive of Down syndrome. Overall, the qualitative diagnosis of Down syndrome for this vase is moderate in strength.

Figure 11: Pottery Vase from Peru dated to between 1200-1500 A.D. This vase is suspected of having Down syndrome-like facial characteristics (Wells 1964; Ebbin et al. 1968). This image was originally published by Wells (1964:223).



Terra-Cotta Figurine (circa 500 A.D.)

Martinez-Frias (2005) briefly describes a terra-cotta figurine that certainly appears to capture the essence of the Down syndrome facial phenotype (figure 12). This figurine comes from the Tolteca culture of Mexico and is dated to around 500 A.D. Martinez-Frias reports that the figurine has short palpebral fissures, oblique eyes, midfacial hypoplasia, an open mouth, and a protruding tongue. Overall, based upon the qualitative evidence and the high-quality image provided by Martinez-Frias (2005), the diagnosis of Down syndrome in this figurine is strong.

Figure 12: Terra-Cotta Figurine from the Tolteca culture of Mexico dated to around 500 A.D. This figurine is arguably one of the highest quality depictions of Down syndrome in material culture. This image was originally published by Martinez-Frias (2005:231).



Tumaco-La Tolita Figurine (circa 500 B.C.)

Bernal and Brecino (2006) argue that a figurine dated to around 500 B.C. has several suggestive characteristics of Down syndrome (Figure 13). This figurine comes from the Tumaco-La Tolita culture, which inhabited the borders of present-day Columbia and Ecuador. The Tumaco-La Tolita culture spanned over 1000 years (600 B.C. – 350 A.D.), and this time period has been divided into pre-classic (600-300 B.C.), classic (300-90 B.C.), and post-classic periods (90 B.C.-350 A.D.). Bernal and Brecino (2006) note that this culture left behind many pottery artifacts depicting everyday life and various health conditions; however, the quality of these depictions changed during these time periods, acquiring characteristics of portraits during the classic period, but being of lesser quality during the pre-classic and post-classic periods. The figurine in question is from the pre-classic period and portrays a somewhat obese individual with upslanted palpebral fissures, a depressed nasal bridge, upturned nose, a small midface, open mouth posture, and mandibular prognathism. Overall, the qualitative evidence that Down syndrome may be depicted in this figurine is strong.

Figure 13: Tumaco-La Tolita Figurine from the Tumaco-La Tolita culture (present-day Columbia and Ecuador) dated to around 500 B.C. This figurine is suspected of having Down syndrome-like facial characteristics and was originally published by (Bernal and Brecino 2006:188-191).

Olmec Figurines (1500 B.C. – 300 A.D.)

Milton and Gonzalo (1974) argue that several Olmec figurines from Meso-America dated from 1500 B.C. – 300 A.D. may depict Down syndrome. Milton and Gonzalo report that these figurines have upslanted palpebral fissures, well-marked epicanthic folds, short noses, broad nasal bridges, brachycephalic head shapes, open mouth postures, and a lower lip that is drawn downward. Kunze and Nippert (1986) have also diagnosed an Olmec figurine with Down syndrome (Figure 14A) because of the presence of slanted palpebral fissures, ocular

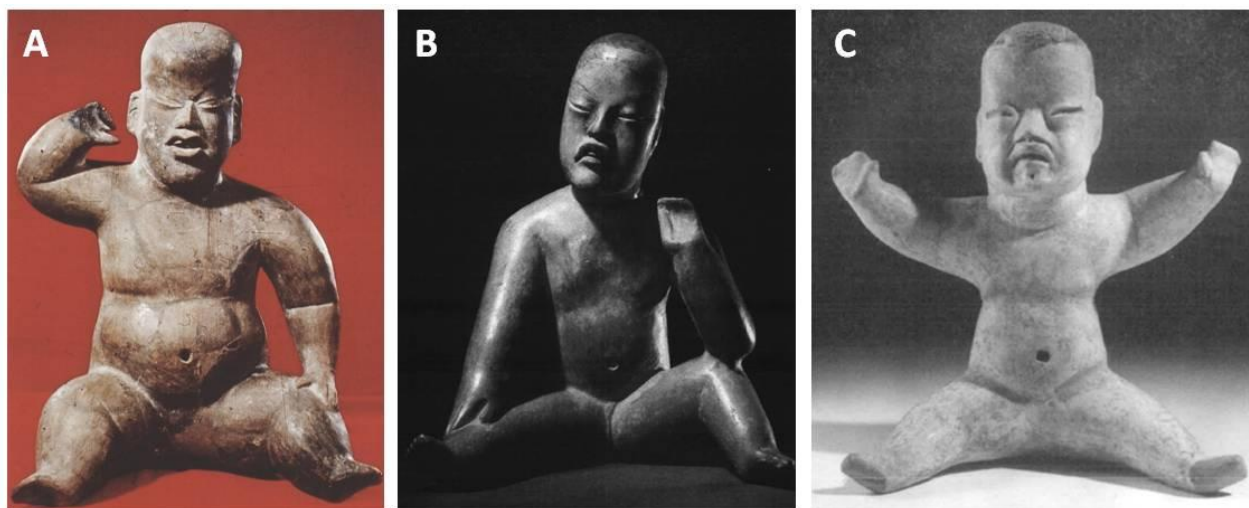


Figure 14: Olmec Figurines from Meso-America dated from 1500 B.C. – 300 A.D. Image A depicts an individual suspected of having Down syndrome-like phenotypic characteristics (Milton and Gonzalo 1974; Kunze and Nippert 1986). Images B and C are Olmec figurines that Pueschel argues do not have Down syndrome-like characteristics. It is clear from the basic body and head shape that the figurines Pueschel analyzed (images B and C) phenotypically differ from the figurines that Milton and Gonzalo and Kunze and Nippert diagnosed with Down syndrome (image A). Image A was originally published by Kunze and Nippert (1986:84). Images B and C were originally published by Pueschel (1998:411-412).

hypotelorism, short extremities, and obesity. In addition to asserting that these figurines depict Down syndrome, Milton and Gonzalo (1974) argue that the religious beliefs of the Olmec culture may have ascribed a high status to individuals with trisomy 21 because they were thought to be the offspring of a mating between humans and the jaguar, which was the most powerful Olmec totem. As evidence for this theory, Milton and Gonzalo (1974:34) direct attention to a painting found in the Oxtotitlan cave, near Chilapa, Mexico in which a senior tribeswoman is seen copulating with a snarling jaguar and note that some Olmec figurines depicted with Down syndrome-like characteristics also have jaguar-like fangs (Milton and Gonzalo 1974). Stratford (1996:4) argues that individuals with trisomy 21 would have been revered as a god-human hybrid for the following reasons: 1) they were born to more senior females of the tribe who had supposedly mated with the jaguar, 2) only a few would survive thus making them rare, and 3) they had striking phenotypic features that needed to be explained somehow. Milton and Gonzalo maintain that without scientific explanations for the cause of specific conditions, the Olmec likely used mystical explanations for the presence of these conditions. However, Pueschel (1998) disagrees and challenges Milton and Gonzalo's assessment that Olmec figurines depict Down syndrome (Figure 14B and 14C). Pueschel asserts that very few models would have been

available for artists to copy given the low likelihood of survival for any individuals born with trisomy 21. Moreover, Pueschel points out that rather than being brachycephalic the figurine heads are actually dolichocephalic. Furthermore, Pueschel disagrees with Milton and Gonzalo's list of Down syndrome-like characteristics present in Olmec figurines by arguing that midfacial hypoplasia frequently seen in Down syndrome is not present, epicanthic folds are not present, and the noses are well-developed in these figurines rather than under-developed as is frequently seen in Down syndrome. Unfortunately these authors all evaluated different figurines. The low-quality images from Milton and Gonzalo (1974:35) make it difficult to discern specific facial characteristics; however, by comparing the outline from the figures provided by Milton and Gonzalo with the higher quality images provided by Kunze and Nippert (1986:84) (Figure 14A) and Pueschel (1998:411-412) (Figure 14B and 14C) it is clear that the figurines that Milton and Gonzalo (1974) and Kunze and Nippert (1986) diagnosed with Down syndrome differ phenotypically from the images provided by Pueschel by exhibiting obesity and different craniofacial morphology. This likely explains many of the differences in interpretation between Milton and Gonzalo and Pueschel for the presence or absence of qualitative traits that are frequently associated with trisomy 21.

Interestingly, there is no single phenotypic trait that is always present in Down syndrome. Rather, it is the combination of several traits that results in the characteristic appearance of the Down syndrome face. If Milton and Gonzalo are correct in arguing that these individuals were thought to result from matings between humans and the jaguar, perhaps this explains the lack of some Down syndrome-like traits and the presence of others because artists may have emphasized some features over others based upon religious beliefs about the jaguar. Moreover, if Pueschel is correct in arguing that few individuals with trisomy 21 would have lived long enough for an artist to use them as a model when creating these statues, which is likely the case due to life-threatening congenital birth defects associated with Down syndrome, then perhaps some statues were created by copying characteristics from older statues or by basing artistic endeavors on descriptions from elders of the few individuals with this condition who occasionally survived for longer periods of time. Based upon the qualitative arguments presented, a diagnosis of Down syndrome for these figurines is controversial because some phenotypic traits are present whereas others are absent. Overall, qualitative evidence that Down syndrome may be depicted in the Olmec figurine published by Kunze and Nippert (1996) is stronger than for the images provided by Pueschel (1998); however, all of these statues have some Down syndrome-like characteristics.

DISCUSSION

On the basis of both material culture and skeletal remains exhibiting Down syndrome-like phenotypes, and basic logic, it is likely that Down syndrome has been present in mankind for as long as chromosome 21 has existed (Megarbane et al. 2009:611; Berg and Korossy 2001:205). Volpe (1986:427) thinks that artists and physicians of the past frequently confused Down syndrome with cretinism, which is often associated with a puffy face, large tongue, and cognitive impairment and therefore overlaps somewhat with Down syndrome in terms of phenotypic expression. Interestingly, the range of soft-tissue variation in Down syndrome faces has seldom been explored; however, variances of facial measurements from individuals with Down syndrome are not significantly different from typical faces (Starbuck et al. 2008). Many of the qualitative arguments for a diagnosis of Down syndrome rest on the assumption that the most common features associated with trisomy 21 ought to be portrayed by artists, but this may not be the case because throughout history the average lifespan of an individual with Down syndrome

was very short and therefore, few models would have been available for an artist to depict. With no other models to work from an artist would have to rely on the phenotypic characteristics present in a particular model who had trisomy 21 and who happened to live longer than other individuals with Down syndrome. This would produce an artistic “founder effect” that may accurately represent the model used but which may not contain all of the phenotypic traits that are known to be associated with Down syndrome today. Furthermore, although Down syndrome faces are thought of as characteristic, slight differences are present in the facial morphology of different ethnic groups (Ferrario et al. 2004; 2005), and Down syndrome faces change shape throughout ontogeny just like typical faces, although the rate of growth for different parts of the face may differ (Frostad 1971; Fink et al. 1975; O’Riordan and Walker 1979; Fischer-Brandies et al. 1986). As a result, many craniofacial morphological forms can be associated with this “characteristic” face because of differences in age, sex, genetic background, and environment.

Interestingly, differences in morphological variation may also occur due to the origin of Down syndrome. Although 95% of individuals with Down syndrome have an entire extra copy of chromosome 21 because of non-disjunction, the other 5% of cases are due to mosaicism or translocation of all or part of chromosome 21 (i.e. segmental trisomy) (Fisher 1983; Hassold et al. 1993; Pueschel 2000). While these individuals are lumped into the same group as individuals with Down syndrome due to non-disjunction, it may be the case that the facial phenotypes of individuals with mosaic or translocation Down syndrome are different. Unfortunately, no study has investigated craniofacial morphological differences between these three types of trisomy 21 because it is incredibly difficult to acquire large sample sizes of individuals with Down syndrome, and even more difficult to acquire large samples of individuals with mosaic or translocation Down syndrome. Interestingly, individuals with mosaicism tend to have milder phenotypic differences and less cognitive impairment (Fishler et al. 1976). In fact, one could make the argument that individuals with mosaic Down syndrome may suffer less frequently from congenital birth defects and perhaps enjoyed a longer average lifespan than individuals with Down syndrome from non-disjunction. Thus, it could be the case that mosaic individuals were portrayed more often by artists throughout history because they were more likely to survive. A similar argument could be made for individuals with Down syndrome from translocation, especially in cases of segmental trisomy where the triplication is small and therefore less likely to extensively disrupt development. Since both mosaic and translocation Down syndrome can manifest themselves with milder forms of the characteristic facial morphology associated with Down syndrome, and since these individuals may have been more likely to live longer life spans, then we again are forced to consider the possibility of an artistic founder-effect, which could explain why some forms of material culture have different degrees of Down syndrome-like traits present.

Other factors affecting whether or not particular pieces of material culture may depict Down syndrome include artistic expression and cultural context. Many artists employ a particular style of artistic expression that may focus on representing individuals realistically or unrealistically. Some styles may exaggerate particular features while other styles may ignore dysmorphic features in favor of producing an idealistic representation of the person portrayed. Artists who were hired to create a piece may also have to alter their artistic style to accommodate the wishes of their employer, which has been shown to be true for artists working for Egyptian kings (Hawass et al. 2010). An artist can also employ multiple styles throughout his or her lifespan and even within the same piece. Additional factors include geographic and temporal

cultural context, which can affect materials available for creating a piece, how an artist portrays individuals, and the ways that cultural values, social structure, and mythology or religion might affect artistic style. Unfortunately for many of the pieces presented in this paper very little is known about the actual intentions of the artists who created the pieces in question. While speculation about artistic intentions can be interesting it doesn't bring us closer to a quantitative assessment of whether or not Down syndrome may be depicted in a particular piece.

Berg and Korossy (2001) critically looked at some of the material culture listed in Appendix A for conclusive evidence of the presence or absence of Down syndrome; however, these authors took an extremely skeptical approach by looking for irrefutable evidence that the condition was present, and not surprisingly they were not convinced of a single case of Down syndrome in pre-1866 material culture. Unfortunately, Berg and Korossy never discuss what evidence would have to be present in a particular piece of material culture to actually convince them that Down syndrome is indeed depicted. It is worth noting that irrefutable evidence of the presence or absence of Down syndrome in historical material culture simply doesn't exist. It will never be possible to karyotype a painting or statue to assess the presence or absence of trisomy 21. Despite having a "characteristic" facial gestalt, no single physical trait is always present in individuals with Down syndrome. The only qualitative way to diagnosis Down syndrome in paintings or figurines is to use phenotypic clues based upon the presence or absence of several different traits. For many paintings and inaccessible artifacts this restricts us to an examination of craniofacial morphology in a two-dimensional photograph that is often oriented in ways that make assessment difficult. Such qualitative analyses based on the presence or absence of traits, or upon arguments of strength (e.g. weak, moderate, strong) such as those used above, are often limited and unsatisfactory. Rather than asking if an individual portrayed in a painting or figurine has diagnostically conclusive evidence of Down syndrome, perhaps the question that we should ask is *could* Down syndrome be portrayed in this particular piece of material culture?

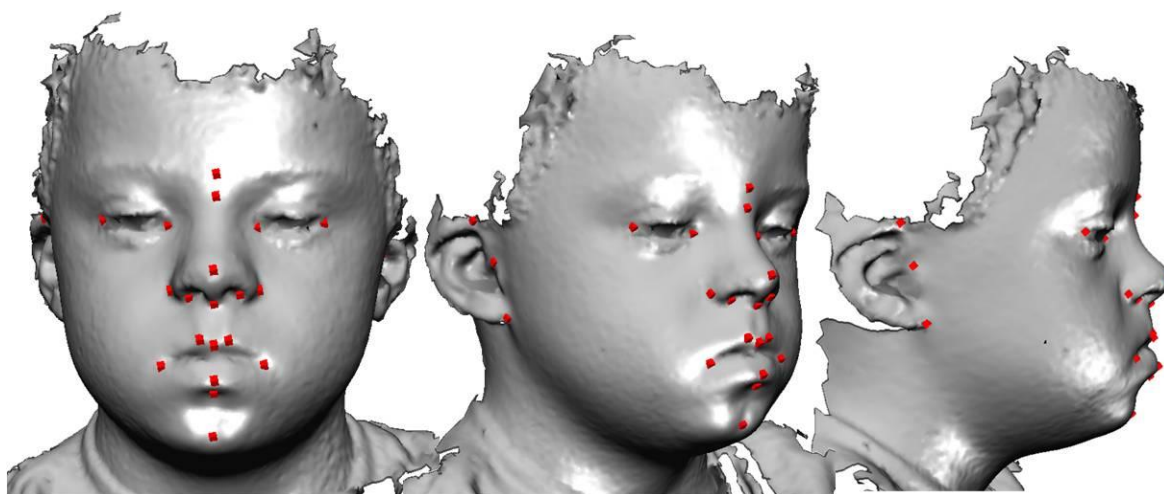


Figure 15: A 3dMD face image of a child with Down syndrome is pictured here with several anatomical landmarks placed upon the face. Using 3dMD patient each 3D image can be manipulated in 3D space by changing size, orientation, texture, and color. A variety of geometric morphometric methods exist for analyzing landmark coordinates and linear distances calculated from landmark coordinate data. Facial texture has been altered on this image to protect identity.

In recent years a large number of quantitative methods, most notably geometric morphometrics, have been developed for measuring and comparing morphological form

(Richtsmeier et al. 2002). The use of anatomical landmarks in geometric morphometric research has become widespread because landmarks are repeatable, provide geometric information in terms of the relative location of structure, and because a variety of methods have been developed to analyze landmark configurations (e.g. Procrustes superimposition; Bookstein 1991; 1997; Rohlf and Slice 1990) or to analyze linear distances calculated from landmark coordinate data (e.g. Euclidean distance matrix analysis; Lele and Richtsmeier 1995; 2001). These analyses can be carried out in two- or three-dimensions. In order to move away from qualitative diagnoses of Down syndrome in material culture, I recommend geometric morphometric tools be used to assess whether or not particular individuals portrayed in paintings or figurines fall into the same craniofacial shape space as individuals who have been medically diagnosed with Down syndrome. In order to carry out an investigation to compare images, one would need to collect 3D soft-tissue facial images of both males and females with Down syndrome from all age ranges and ethnic affiliations. Three-dimensional images could then be oriented to match the face in question and converted to 2D images. Afterwards, landmarks can be collected from all images in the comparative sample and the piece of material culture in question. Researchers can then determine if the individual portrayed in material culture falls into the same multivariate shape-space as individuals known to have Down syndrome (Figure 15). Rather than relying on the presence or absence of specific traits that are “characteristic” of individuals with trisomy 21, this analysis would take into account the range of variation present in Down syndrome faces, which is often underappreciated by individuals who are not actively working with large samples of individuals with trisomy 21. The accumulation of a large 3D dataset of individuals with Down syndrome is currently underway and once a sufficient sample size is obtained I intend to carry out morphometric analyses on several of the pieces of material culture presented in this paper. Such an investigation is probably as close as we can ever get to diagnostically conclusive evidence for or against the presence of trisomy 21 in historical forms of material culture.

REFERENCES

- Allen, G.
1974 Aetiology of Down's syndrome inferred by Waardenburg in 1932. *Nature* 250(465):436-7.
- Andrle, M., W. Fiedler, A. Rett, P. Ambros, and D. Schweizer.
1979 A case of trisomy 22 in *Pongo pygmaeus*. *Cytogenetics and Cell Genetics* 24(1):1-6.
- Berg, J. M., and M. Korossy.
2001 Down syndrome before Down: a retrospect. *American Journal of Medical Genetics* 102 (2):205-11.
- Berkson, G.
2004 Intellectual and physical disabilities in prehistory and early civilization. *Mental Retardation* 42(3):195-208.

Bernal, J. E., and I. Briceno.

2006 Genetic and other diseases in the pottery of Tumaco-La Tolita culture in Colombia-Ecuador. *Clinical Genetics* 70(3):188-91.

Bersu, E. T.

1980 Anatomical analysis of the developmental effects of aneuploidy in man: the Down syndrome. *American Journal of Medical Genetics* 5(4):399-420.

Bookstein, F. L.

1997 Landmark methods for forms without landmarks: morphometrics of group differences in outline shape. *Medical Image Analysis* 1(3):225-43.

Bookstein, FL.

1991 *Morphometric tools for landmark data: geometry and biology*. Cambridge: Cambridge University Press.

Brothwell, D. R.

1960 A possible case of mongolism in a Saxon population. *Annals of Human Genetics* 24:141-50.

Center for Disease Control and Prevention.

2006 Center for Disease Control and Prevention: Improved national prevalence estimates for 18 selected major birth defects – United States, 1999—2001. *Morbidity and Mortality Weekly Report* 54(51&52):1301-1305.

Chumlea, W. C., R. M. Malina, G. L. Rarick, and V. D. Seefeldt.

1979 Growth of short bones of the hand in children with Down's syndrome. *Journal of Mental Deficiency Research* 23(2):137-50.

Collmann, R.D., and A. Stoller.

1963 A life table for Mongols in Victoria, Australia. *Journal of Mental Deficiency Research* 7:53-59.

Cone, T.E.

1964 An infant with some facial features of Mongolism. *American Journal of Diseases of Children* 106:333-334.

1968 Is Down's Syndrome a Modern Disease? *The Lancet* 292(7572):829.

Czarnetski, A, N Blin, and C.M. Pusch.

2003 Down's syndrome in ancient Europe. *The Lancet* 362(9388):1000.

Diamandopoulos, A. A., K. G. Rakatsanis, and N. Diamantopoulos.

1997 A neolithic case of Down syndrome. *Journal of the History of Neurosciences* 6(1):86-9.

Dobson, R.

2003 Painting is earliest example of portrayal of Down's syndrome. *British Medical Journal* 326(7381):126.

Down, J.L.

1866 Observations on an Ethic Classification of Idiots. *Clinical Lectures and Reports by the Medical and Surgical Staff* 3:259-262.

Ebbin, A.J., C.W. Heath, and J. Garcia.

1968 Is Down's Syndrome a Modern Disease. *The Lancet* 292(7564):404.

Einfeld, S. L., and R. Brown.

2010 Down syndrome--new prospects for an ancient disorder. *Journal of the American Medical Association* 303(24):2525-6.

Ferrario VF, C. Dellavia, G. Zanotti, and C. Sforza.

2004 Soft Tissue Facial Anthropometry in Down Syndrome Subjects. *Journal of Craniofacial Surgery* 15(3):528-532.

Ferrario VF, Dellavia C, Colombo A, and Sforza C.

2004 Three-dimensional assessment of nose and lip morphology in subjects with down syndrome. *Annals of Plastic Surgery* 53(6):577-583.

Fink GB, Madaus WK, and Walker GF.

1975 A Quantitative Study of the Face in Down's Syndrome. *American Journal of Orthodontics* 67(5):540-553.

Fischer-Brandies H. RGS, and E. Fischer-Brandies.

1986 Craniofacial Development in Patients with Down's Syndrome from Birth to 14 Years of Age. *European Journal of Orthodontics* 8(35-42).

Fisher, W. L.

1983 Quantitative and Qualitative Characteristics of the Face in Down's Syndrome. *The Journal of the Michigan Dental Association* 65(2):105 -107.

Fishler, K., R. Koch, and G. N. Donnell.

1976 Comparison of mental development in individuals with mosaic and trisomy 21 Down's syndrome. *Pediatrics* 58(5):744-8.

Fraser, J., and A.K. Mitchell.

1876-1877 Idiocy; a report of a case with autopsy. *The Journal of Mental Science* 23:169-179.

Frostad, W. A., J. F. Cleall, and L. C. Melosky.

1971 Craniofacial Complex in the Trisomy 21 Syndrome (Down's Syndrome). *Archives of Oral Biology* 16:707-722.

Gardiner, K., A. Fortna, L. Bechtel, and M. T. Davisson.

2003 Mouse models of Down syndrome: how useful can they be? Comparison of the gene content of human chromosome 21 with orthologous mouse genomic regions. *Gene* 318:137-47.

Garrod, A.

1898 Cases illustrating the association of congenital heart disease with the mongolian type of idiocy. *The British Medical Journal* 1255.

Gollesz, V.

1963 Retardation of somatic development in Down's disease (mongolism). *Acta Morphologica Academiae Scientiarum Hungaricae* 12:85-102.

Greig, D.M.

1927a The skull of the Mongolian imbecile. *Edinburgh Medical Journal* 34:321-339.

1927b The skull of the Mongolian imbecile. *Edinburgh Medical Journal* 34:253-274.

Hall, B.

1966 Mongolism in newborn infants. An examination of the criteria for recognition and some speculations on the pathogenic activity of the chromosomal abnormality. *Clinical Pediatrics (Phila)* 5(1):4-12.

Hassold, T., P. A. Hunt, and S. Sherman.

1993 Trisomy in humans: incidence, origin and etiology. *Current Opinion in Genetics & Development* 3(3):398-403.

Hattori, M., A. Fujiyama, T. D. Taylor, H. Watanabe, T. Yada, H. S. Park, A. Toyoda, K. Ishii, Y. Totoki, D. K. Choi, Y. Groner, E. Soeda, M. Ohki, T. Takagi, Y. Sakaki, S. Taudien, K. Blechschmidt, A. Polley, U. Menzel, J. Delabar, K. Kumpf, R. Lehmann, D. Patterson, K. Reichwald, A. Rump, M. Schillhabel, A. Schudy, W. Zimmermann, A. Rosenthal, J. Kudoh, K. Schibuya, K. Kawasaki, S. Asakawa, A. Shintani, T. Sasaki, K. Nagamine, S. Mitsuyama, S. E. Antonarakis, S. Minoshima, N. Shimizu, G. Nordsiek, K. Hornischer, P. Brant, M. Scharfe, O. Schon, A. Desario, J. Reichelt, G. Kauer, H. Blocker, J. Ramser, A. Beck, S. Klages, S. Hennig, L. Riesselmann, E. Dagand, T. Haaf, S. Wehrmeyer, K. Borzym, K. Gardiner, D. Nizetic, F. Francis, H. Lehrach, R. Reinhardt, and M. L. Yaspo.

2000. The DNA sequence of human chromosome 21. *Nature* 405(6784):311-9.

Hawass, Z., Y. Gad, S. Ismail, R. Khairat, D. Fathalla, N. Hasan, A. Ahmed, H. Elleithy, M.

Ball, F. Gaballah, S. Wasef, M. Fateen, H. Amer, P. Gostner, A. Selim, A. Zink, and C. Puesch.

2010 Ancestry and pathology in King Tutankhamun's family. *Journal of the American Medical Association* 303(7):638-647.

Hook, E. B.

1989 Issues pertaining to the impact and etiology of trisomy 21 and other aneuploidy in humans; a consideration of evolutionary implications, maternal age mechanisms, and other matters. *Progress in Clinical and Biological Research* 311:1-27.

Jones, R.

1890 The mouth in backward children of mongolian type. *The Journal of Mental Science* 36:187-190.

Kasai, F., E. Takahashi, K. Koyama, K. Terao, Y. Suto, K. Tokunaga, Y. Nakamura, and M. Hirai.

2000 Comparative FISH mapping of the ancestral fusion point of human chromosome 2. *Chromosome Research* 8(8):727-35.

Kisling, E.

1966 Cranial Morphology in Down's Syndrome: A Comparative Roentgencephalometric Study in Adult Males, Orthodontic Department, Royal Danish Dental College Copenhagen, Copenhagen.

Kugel, R. B., and D. Reque.

1961 A comparison of mongoloid children. *Journal of the American Medical Association* 175:959-61.

Kunze, J., and I. Nippert.

1986 *Genetics and Malformations in Art*. Berlin: Berlin.

Kuppermann, M., L. A. Learman, E. Gates, S. E. Gregorich, R. F. Nease, Jr., J. Lewis, and A. E. Washington.

2006 Beyond race or ethnicity and socioeconomic status: predictors of prenatal testing for Down syndrome. *Obstetrics & Gynecology* 107(5):1087-97.

Lele, S., and J. T. Richtsmeier.

1991 Euclidean distance matrix analysis: a coordinate-free approach for comparing biological shapes using landmark data. *American Journal of Physical Anthropology* 86(3):415-27.

Lele, S.R. , and J.T. Richtsmeier.

2001 *An Invariant Approach to Statistical Analyses of Shape*. New York: Chapman and Hall/CRC.

Levitas, A. S., and C. S. Reid.

2003 An angel with Down syndrome in a sixteenth century Flemish Nativity painting. *American Journal of Medical Genetics* 116A(4):399-405.

Martinez-Frias, M. L.

2005 The real earliest historical evidence of Down syndrome. *American Journal of Medical Genetics* 132A(2):231.

McClure, H. M., K. H. Belden, W. A. Pieper, and C. B. Jacobson.

1969 Autosomal trisomy in a chimpanzee: resemblance to Down's syndrome. *Science* 165 (897):1010-2.

Megarbane, A., A. Ravel, C. Mircher, F. Sturtz, Y. Grattau, M. O. Rethore, J. M. Delabar, and W. C. Mobley.

2009 The 50th anniversary of the discovery of trisomy 21: the past, present, and future of research and treatment of Down syndrome. *Journal of Medical Genetics* 11(9):611-6.

Milton, G., and R. Milton and Gonzalo.

1974 Jaguar Cult -- Down's Syndrome -- Were -- Jaguar. *Expedition* 16(4):33-37.

Mirkinson, A.E.

1968 Is Down's Syndrome a Modern Disease? *The Lancet*:103.

Muir, J.

1903 An analysis of twenty-six cases of Mongolism. *Archives of Pediatrics* 20(3):161-169.

O'Riordan, M.W. and G.F. Walker.

1979 Dimensional and Proportional Characteristics of the Face in Down's Syndrome. *Journal of Dentistry for the Handicapped* 4(1):6-9.

Oliver, C.A.

1891 A clinical study of the ocular symptoms found in the so-called Mongolian type of idiocy. *Transactions* 6:140-148.

Penrose, L. S.

1951 Maternal age in familial mongolism. *The Journal of Mental Science* 97(409):738-47.

Pueschel, S. M.

1998 Do Olmec figurines resemble children with specific dysmorphology syndromes? *Journal of the History of Medicine and Allied Sciences* 53(4):407-15.

Pueschel, S.M.

2000 *A Parent's Guide to Down Syndrome: Towards a Brighter Future*. New York: Paul H Brookes Publishing Company.

Redman, R.S., B.L. Shapiro, and R.J. Gorlin.

1966 Measurement of normal and reportedly malformed palatal vaults. III. Down's syndrome (trisomy 21, mongolism). *Journal of Dental Research* 45(2):162-165.

Richard, F., and B. Dutrillaux.

1998 Origin of human chromosome 21 and its consequences: a 50-million-year-old story. *Chromosome Research* 6(4):263-8.

Richards, B.W.

1968 Is Down's Syndrome a Modern Disease? *The Lancet* 2(7563):353-354.

Richtsmeier, J. T., V. B. DeLeon, and S. R. Lele.

2002 The promise of geometric morphometrics. *American Journal of Physical Anthropology Supplement* 35:63-91.

Roche, A. F., F. S. Seward, and S. Sunderland.

1961 Nonmetrical observations on cranial roentgenograms in mongolism. *The American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine* 85:659-62.

Rohlf, F.J., and D.E. Slice.

1990 Extensions of the Procrustes method for the optimal superimposition of landmarks. *Systematic Zoology* 39:40-59.

Ruhrah, J.

1935 Cretin or Mongol or both together? *American Journal of Diseases of Children* 49:477-478.

Salter, V., and M. Ramachandran.

2008 Medical conditions in works of art. *British Journal of Hospital Medicine (London)* 69 (2):91-4.

Smith, T.T.

1896 A peculiarity in the shape of the hand in idiots of the Mongol type. *Pediatrics* 2:315-320.

Spitzer, R., and M. I. Robinson.

1955 Radiological changes in teeth and skull in mental defectives. *The British Journal of Radiology* 28(327):117-27.

Starbuck, J.M., K. Willmore, R. Reeves, and J.T. Richtsmeier.

2008 Quantitative comparison of midface morphology in Down syndrome individuals and unaffected siblings. *American Journal of Physical Anthropology Supplement* 46:200.

Stimson, C. W., R. Geake, and H. Weir.

1968 Effects of early institutionalization on growth and development of young children with Down's syndrome. *Michigan Medical Journal* 67(19):1213-8.

Stratford, B.

1982 Down's syndrome at the court of Mantua. *Maternal and Child Health* 7:250-254.

1996 In the beginning. *New approaches to Down syndrome*. London: Cassell Publishers; 3-11.

Townsend, G.

1987 A correlative analysis of dental crown dimensions in individuals with Down syndrome. *Human Biology* 59(3):537-48.

Volpe, E. P.

1986 Is Down syndrome a modern disease? *Perspectives in Biology and Medicine* 29(3 Pt 1):423-36.

von Hofe, F. H.

1922 A report of 150 cases of Mongolian idiocy. *Archives of Pediatrics* 39(737):737-740.

Walker, P.L., D.C. Cook, R. Ward, E. Braunstein, and M. Davee.

1991 A Down Syndrome-like Congenital Disorder in a Prehistoric California Indian. *American Journal of Physical Anthropology* 34(S12).

Ward, O. C.

2004 Further early historical evidence of Down syndrome. *American Journal of Medical Genetics* 126A(2):220.

Wells, C.

1964 *Bones, Bodies, and Disease: Evidence of Disease and Abnormality in Early Man*. Edited by G. Daniel, *Ancient Peoples and Places*. New York: Frederick A. Praeger Publishers.

Wienberg, J., A. Jauch, H. J. Ludecke, G. Senger, B. Horsthemke, U. Claussen, T. Cremer, N. Arnold, and C. Lengauer.

1994 The origin of human chromosome 2 analyzed by comparative chromosome mapping with a DNA microlibrary. *Chromosome Research* 2(5):405-10.

Yunis, J. J., and O. Prakash.

1982 The origin of man: a chromosomal pictorial legacy. *Science* 215(4539):1525-30.

Zellweger, H.

1968 Is Down's Syndrome a Modern Disease? *The Lancet* 2(7565):458.

APPENDIX A

Skeletal remains and material culture that may depict or be associated with Down syndrome					
Name	Type	Age	Location (Culture)	Creator	Reference
SRI-3 Skeletal remains	Skeletal material	5200 B.C.	Santa Rosa Island, California	N/A	Walker et al. 1991
Skull	Skeletal material	550 B.C.	Tauberbischofsheim, Germany	N/A	Czarnetzki et al. 2003
Breedon-on-the-Hill skull	Skeletal material	700-900 A.D.	Leicestershire, England	N/A	Brothwell 1960; Stratford 1996
Lady Cockburn and her Children	Painting	~1773	England	Joshua Reynolds	Zellweger 1968; Volpe 1986; Pueschel 2000; Ward 2004
The Adoration of the Shepherd	Painting	1618 A.D.	Antwerp, Belgium	Jacob Jordaens	Zellweger 1968; Stratford 1996
Satyr with Peasants	Painting	1635-1640 A.D.	Antwerp, Belgium	Jacob Jordaens	Zellweger 1968; Volpe 1986
Ecce-homo-scene	Painting	1505 A.D.		Craftsman of the Aachen altar	Kunze and Nippert 1986
Madonna and Child	Painting	~1460 A.D.	Mantua, Italy	Andrea Mantegna	Cone 1964; Stratford 1982; 1986; Pueschel 2000; Ward 2004
Virgin and Child	Painting	~1460 A.D.	Mantua, Italy	Andrea Mantegna	Ruhrah 1935; Stratford 1982; 1986; Cone 1964; Volpe 1996; Ward 2004
Virgin and Child with Saints Jerome and Louis of Toulouse	Painting	~1455 A.D.	Mantua, Italy	Andrea Mantegna	Not referenced before
The Adoration of the Christ Child	Painting	~1515 A.D.	Belgium or Germany	Not certain	Levitas and Reid 2003; Dobson 2003; Berkson 2004
Neolithic Idol	Figurine	~5000 B.C.	West Thessaly, Greece	Unknown	Diamandopoulos et al. 1997
Egyptian Figurine	Figurine	~100 A.D.	Egypt	Unknown	Kunze and Nippert 1986
Goddess with a Turban of Pearls	Figurine	400-800 A.D.	Mexico	Unknown	Kunze and Nippert 1986
Pottery Vase	Vase	1200-1500 A.D.	Peru	Unknown	Wells 1964; Ebbin et al. 1968
Terra-Cotta figurine	Figurine	~500 A.D.	Mexico (Tolteca)	Unknown	Martinez-Frias 2005
Tumaco-La Tolita Figurine	Figurine	~500 B.C.	Columbia/Ecuador	Unknown	Bernal and Brecino 2006
Olmec Figurines	Figurine	1500 B.C.-300 A.D.	Meso-America	Unknown	Gonzalo 1974; Stratford 1996; Pueschel 1998